# ELECTRICALLY TUNABLE HANDSET ANTENNA

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**Communications Group**
**University of Sheffield, UK**

# Tunable Antennas - Cognitive Radio

Reconfiguring and tuning handset antennas over frequency range 100 MHz to 6 GHz

- Varactor tuning
- MEMs switches
- Liquid crystal tuning

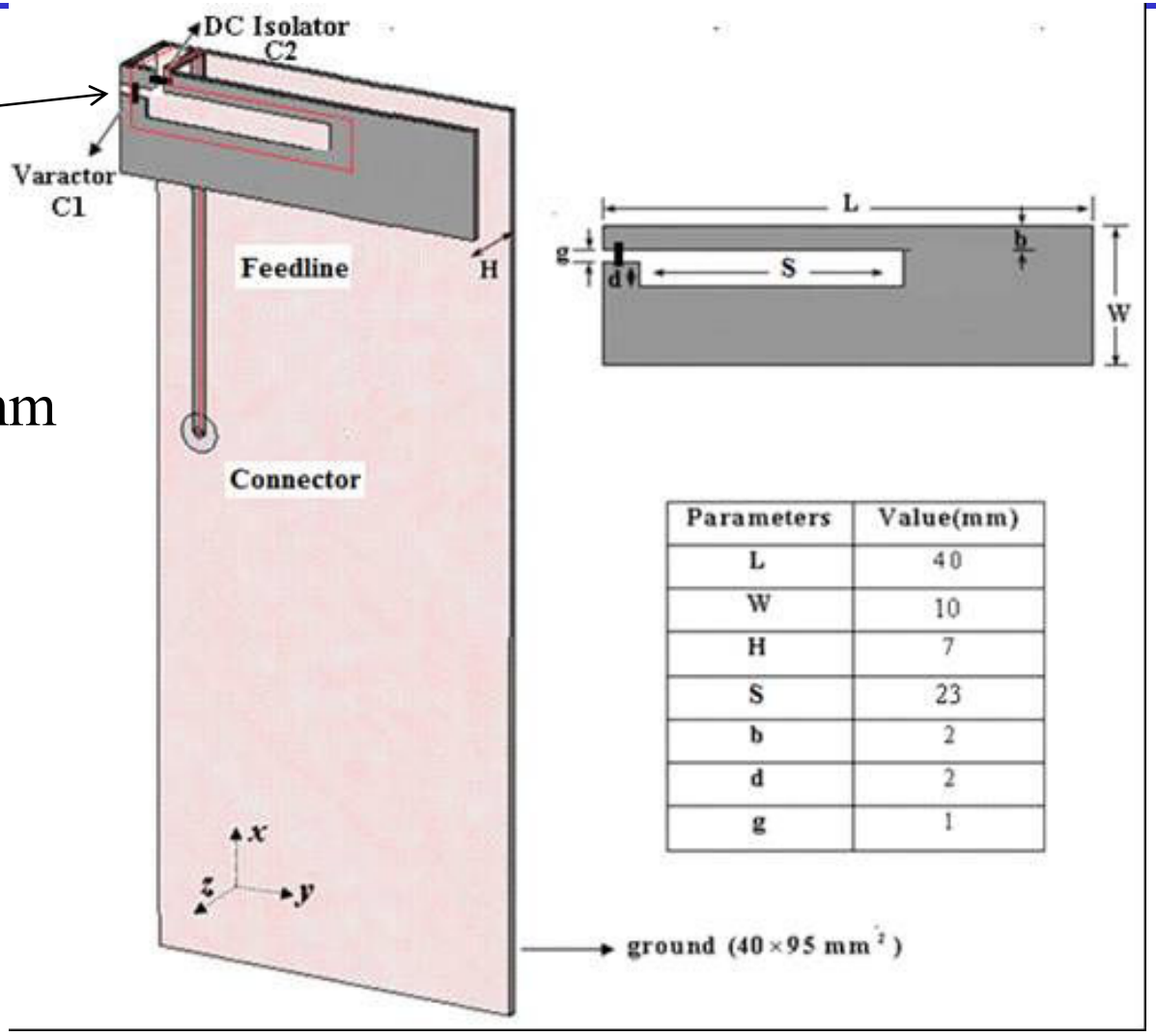
Concepts developed for future integration

# Basic PIFA antenna

Varactor C1

PCB 95x40mm

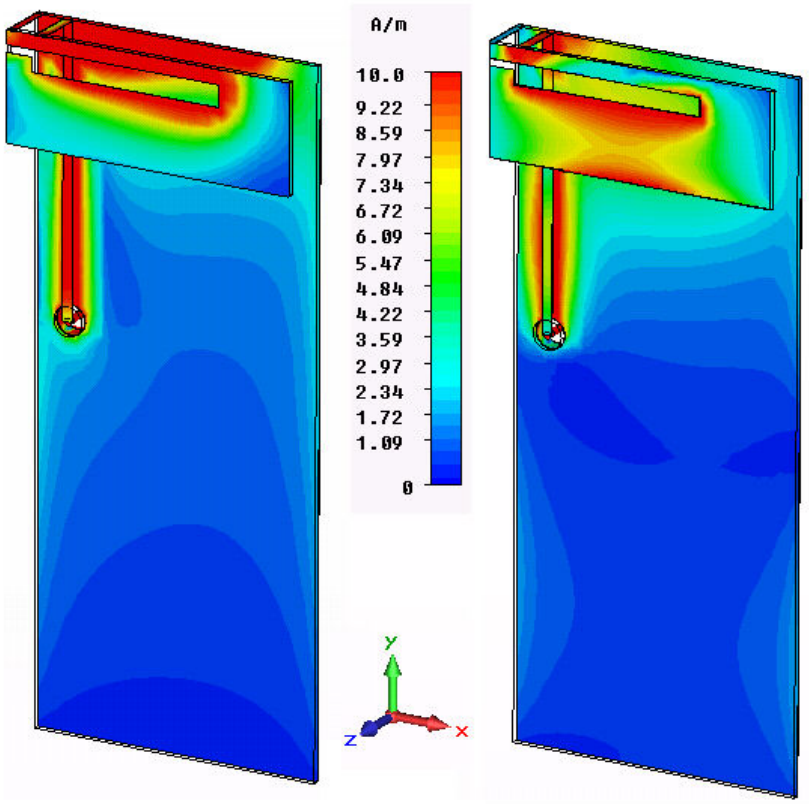
W = 10mm
H = 7mm




| Parameters | Value(mm) |
|---|---|
| L | 40 |
| W | 10 |
| H | 7 |
| S | 23 |
| b | 2 |
| d | 2 |
| g | 1 |

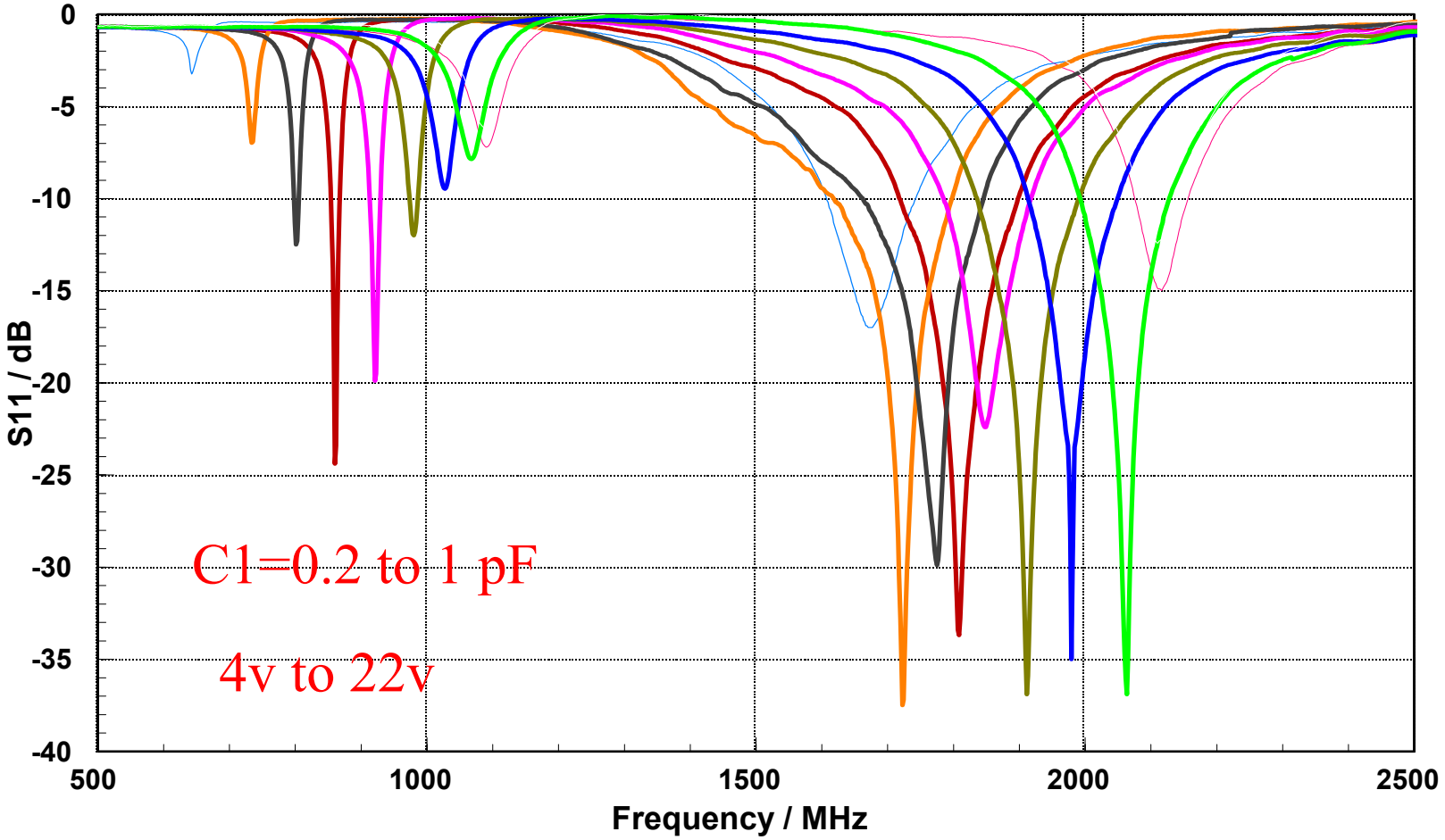
# Mobile telephone bands

## 820-960MHz  1710-2175MHz



# PIFA tuned for mobile telephone bands 800-2020 MHz

## Measured

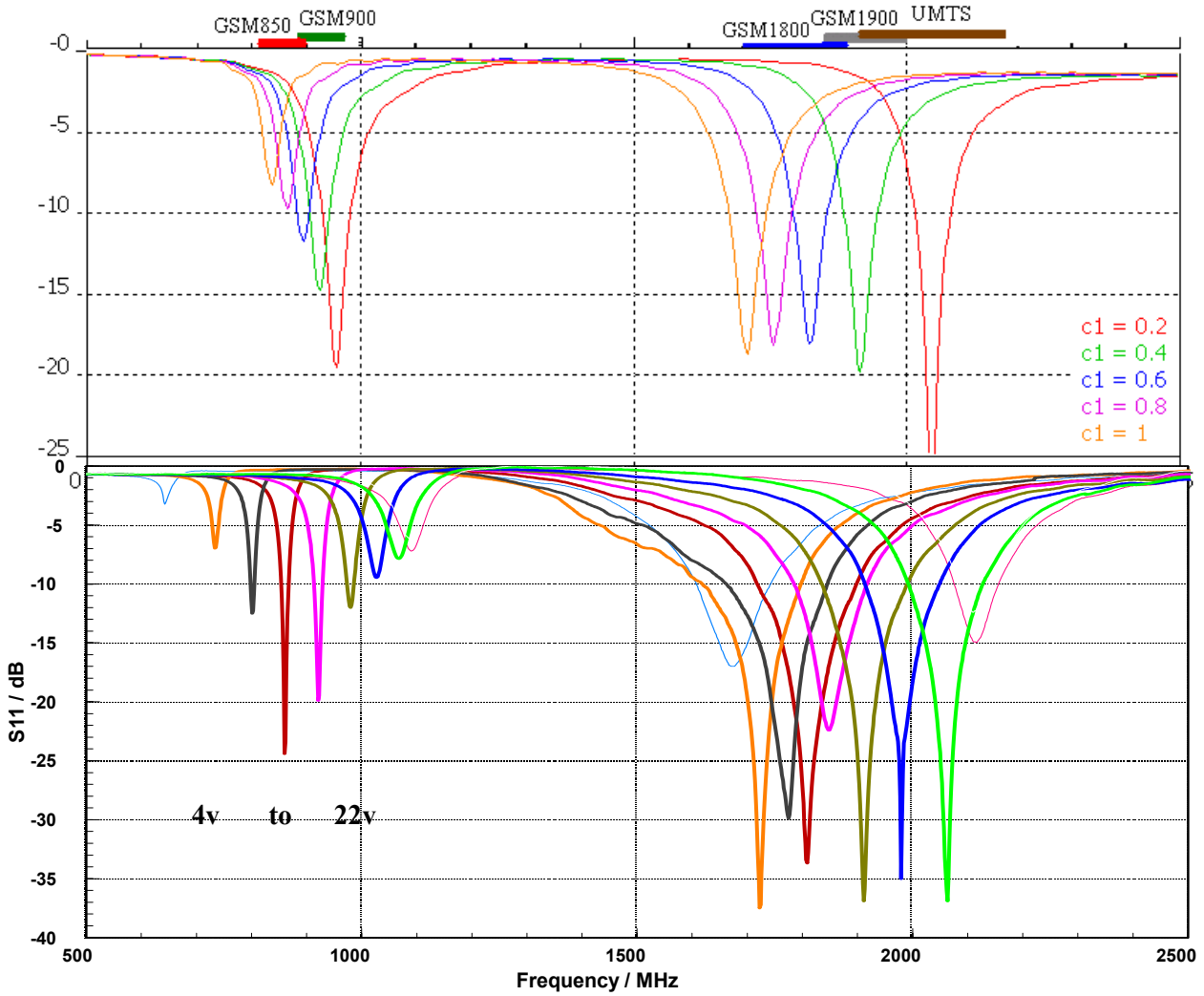


# PIFA tuned for mobile telephone bands 800-2020 MHz

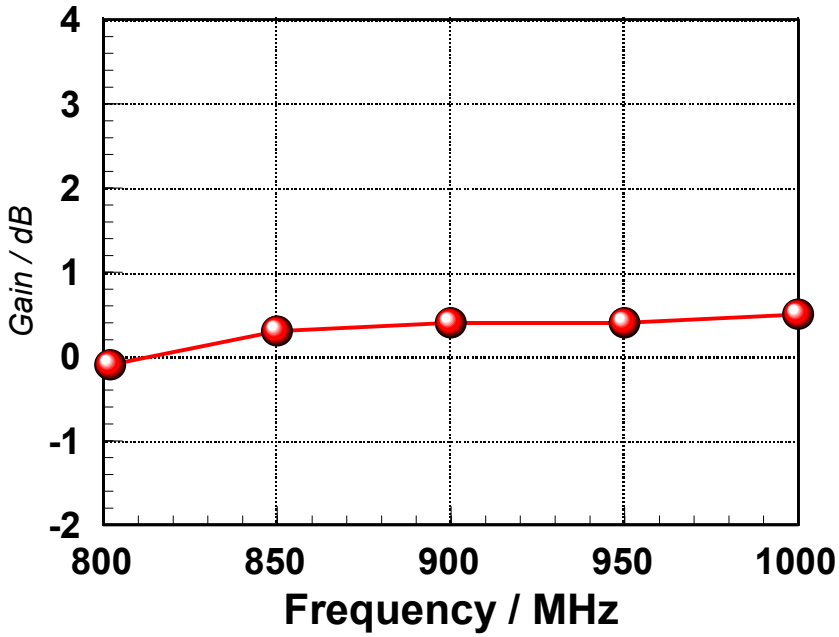
simulated

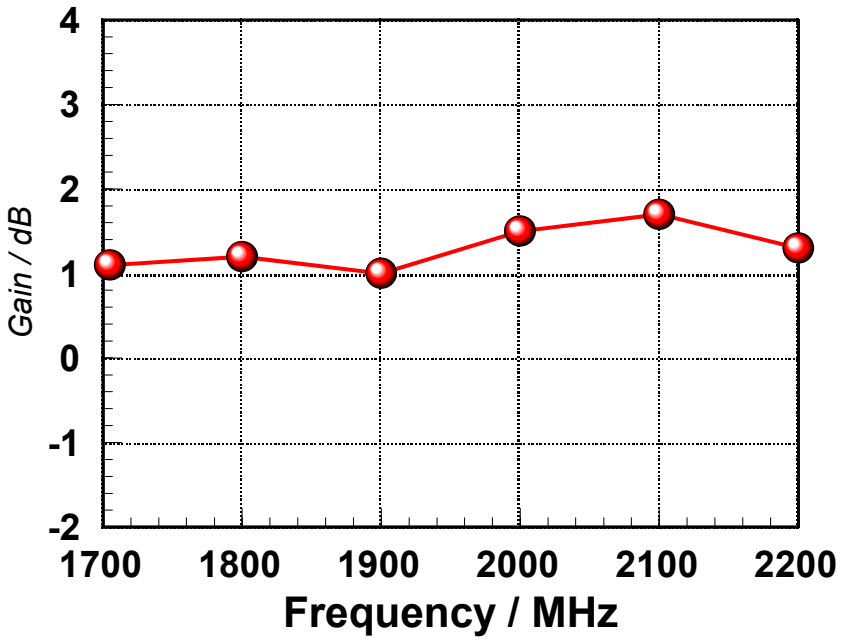
C1=0.2 to 1 pF

measured



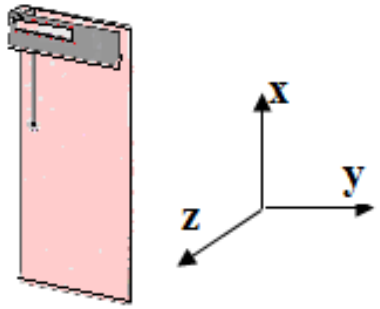
# Measured gains



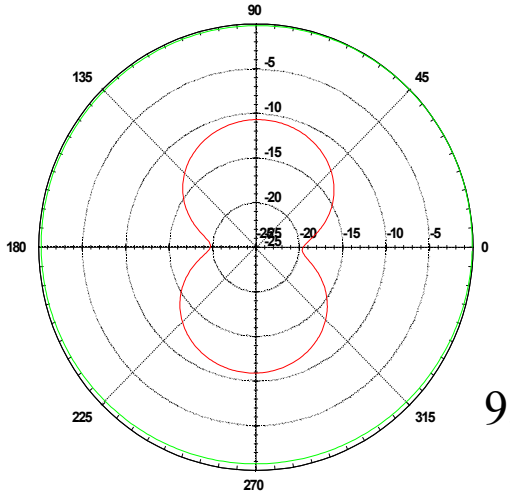

Efficiencies 80-90%

# Measured radiation patterns

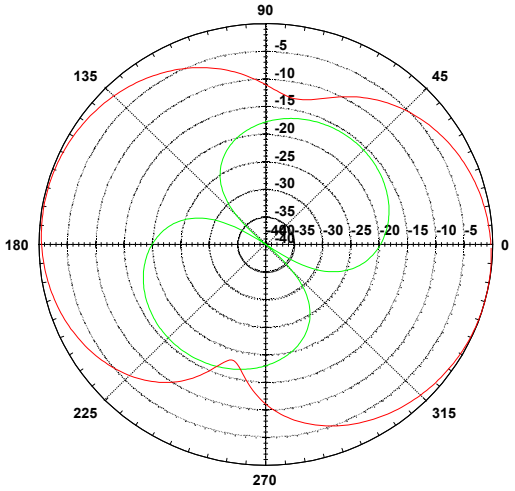



Normalized power pattern Theta

Normalized power pattern Phi

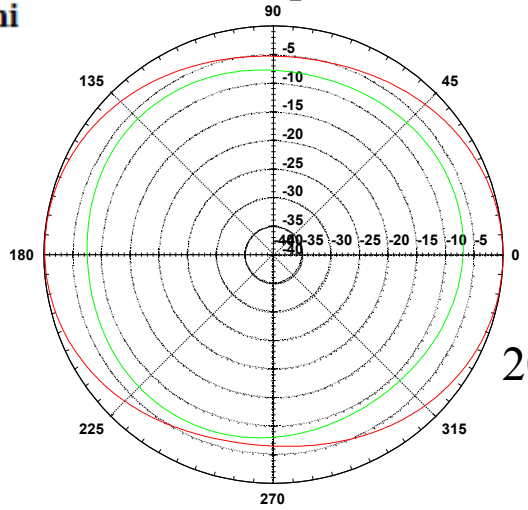



950MHz

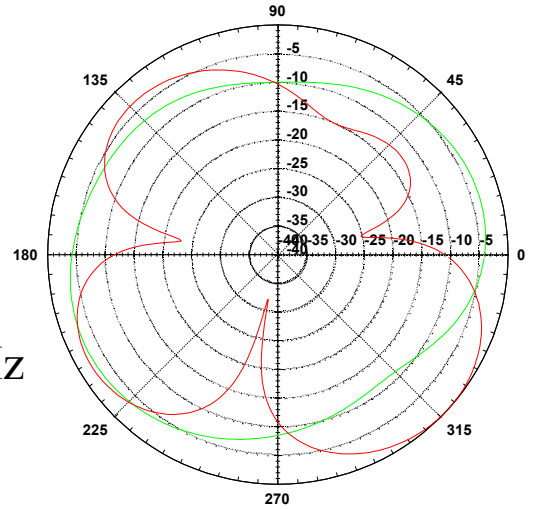



x-z plane

y-z plane




2050MHz



# FM and DVB-H (TV) bands

# 76-108MHz

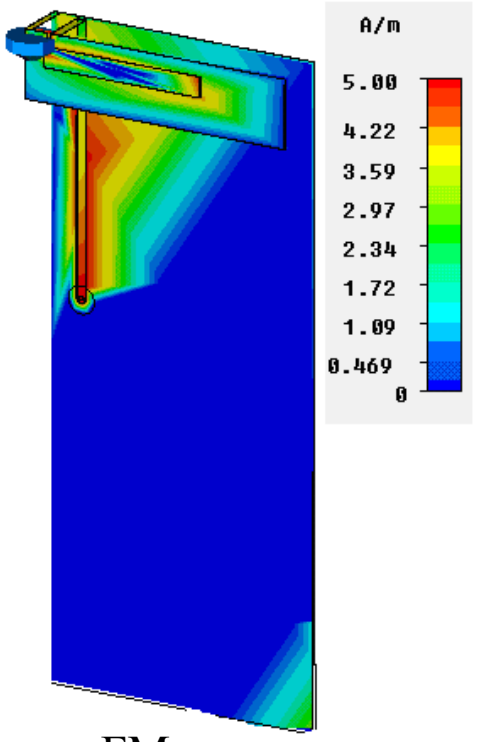
# 470-710MHz

# Varactor C1 with matching circuit

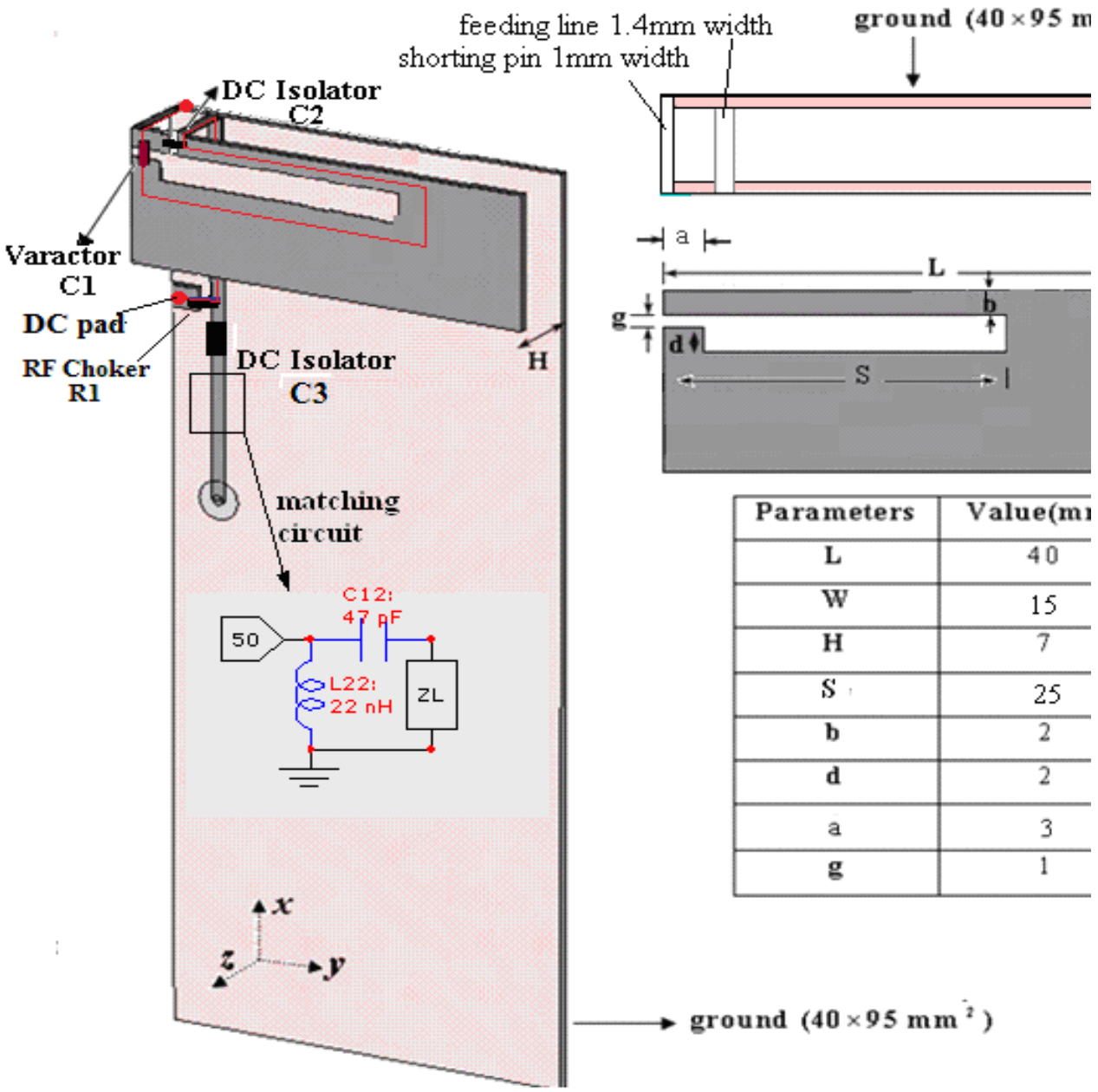
The University of Sheffield
Communications Research Group

# PIFA tuned for FM and DVB-H

Varactor C1
1-6.5pF DVB tuning

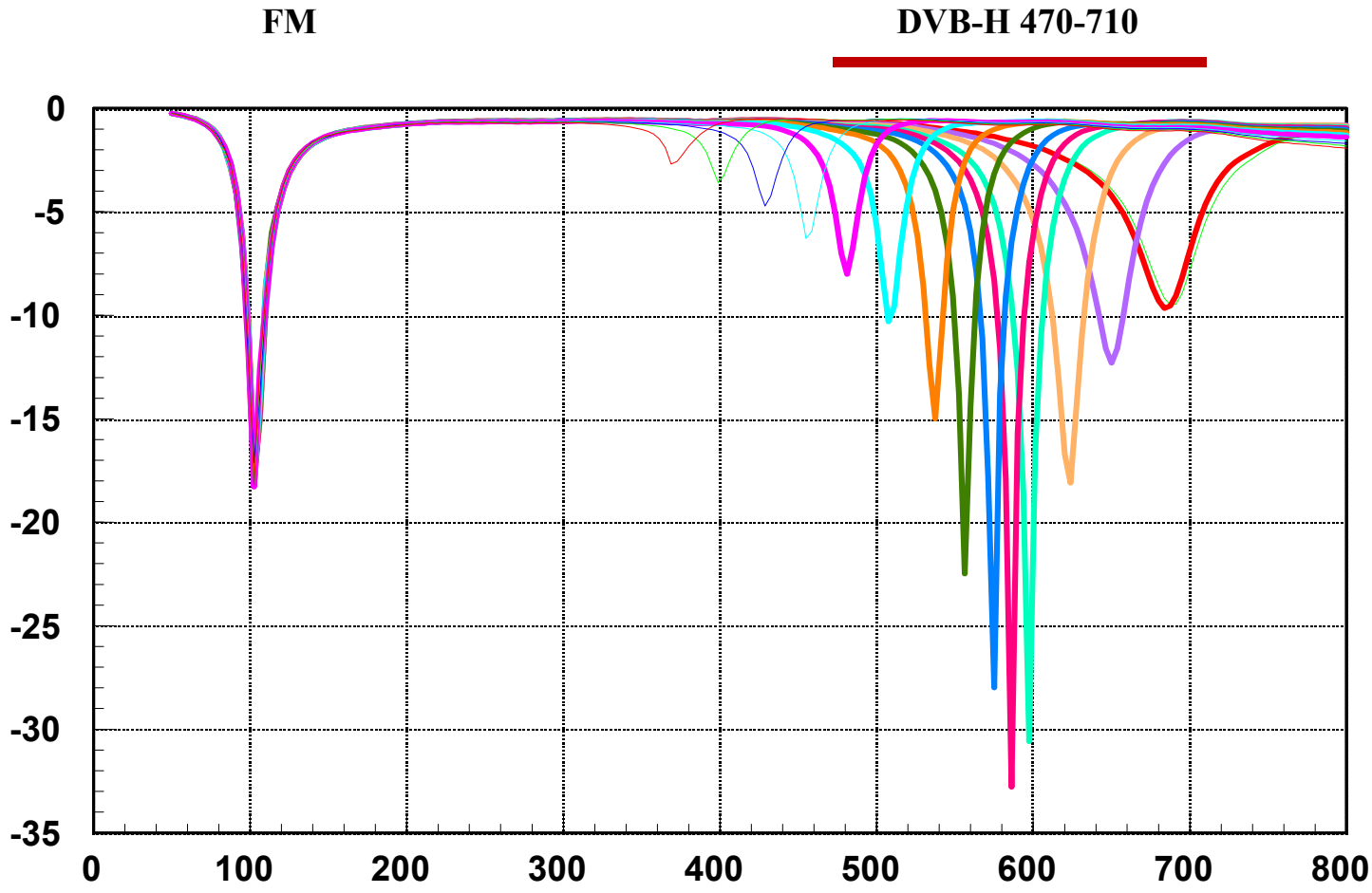



FM



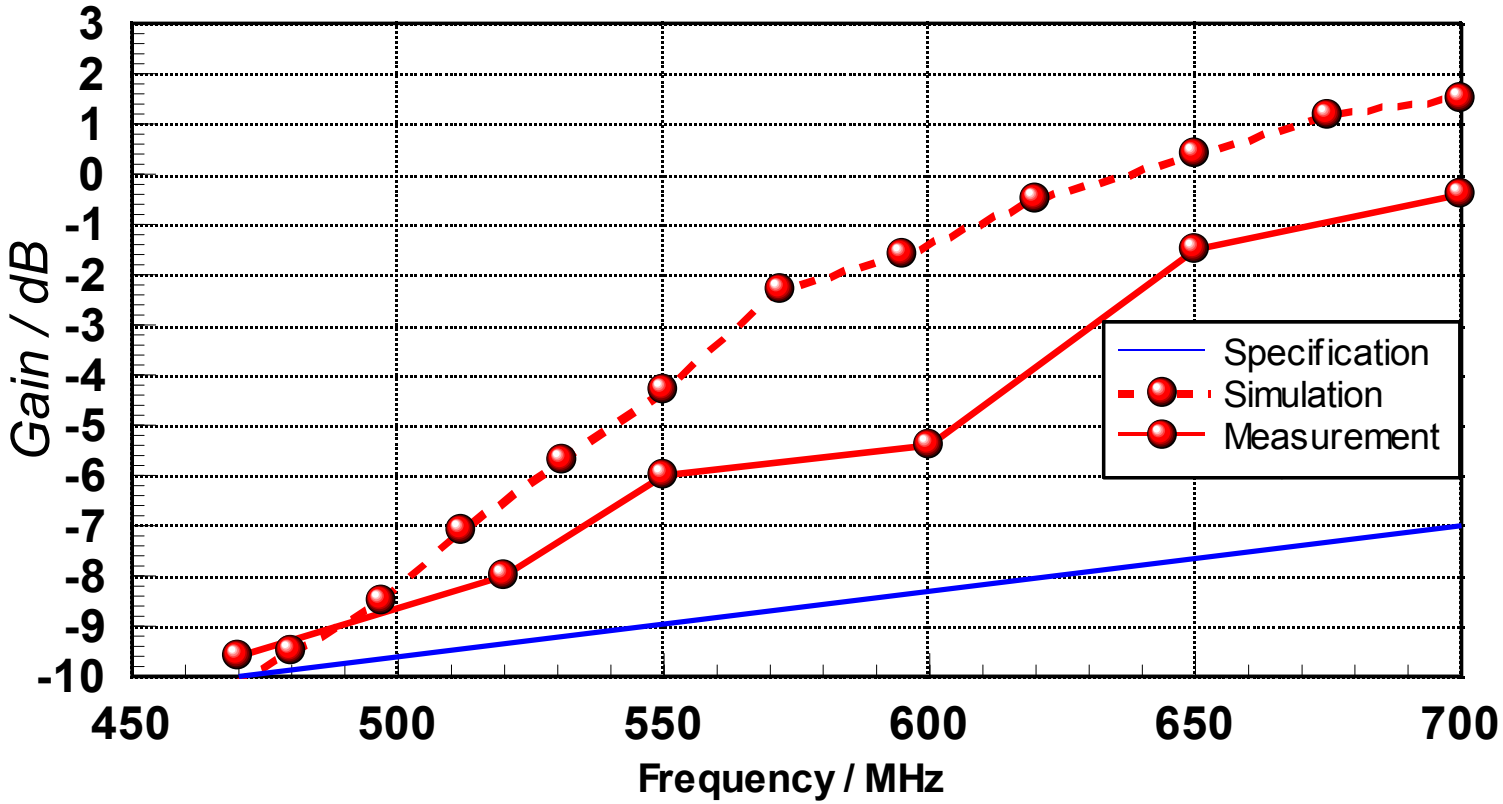

| Parameters | Value(m |
|---|---|
| L | 40 |
| W | 15 |
| H | 7 |
| S | 25 |
| b | 2 |
| d | 2 |
| a | 3 |
| g | 1 |

# Simulated reflection coefficient FM & DVB-H



# DVB-H Radiation patterns and Gain

## Radiation patterns are Omnidirectional

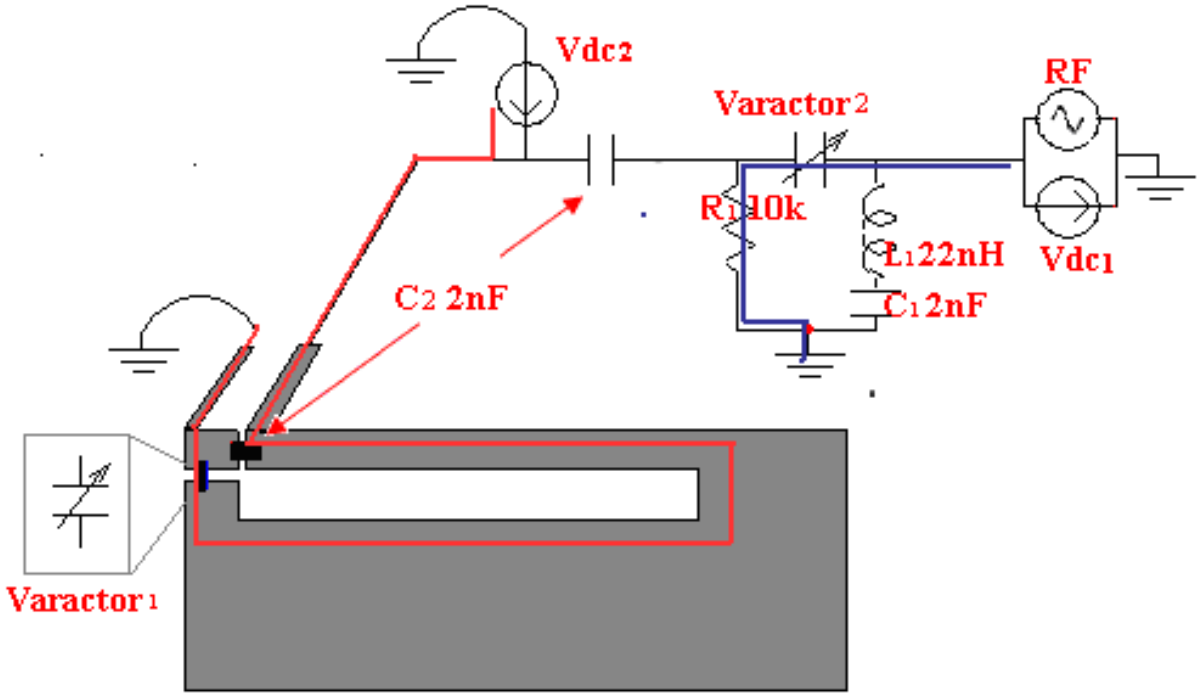



Gain increases by 2 dB at lower end if PCB increased to 115x60mm

# Subjective FM performance

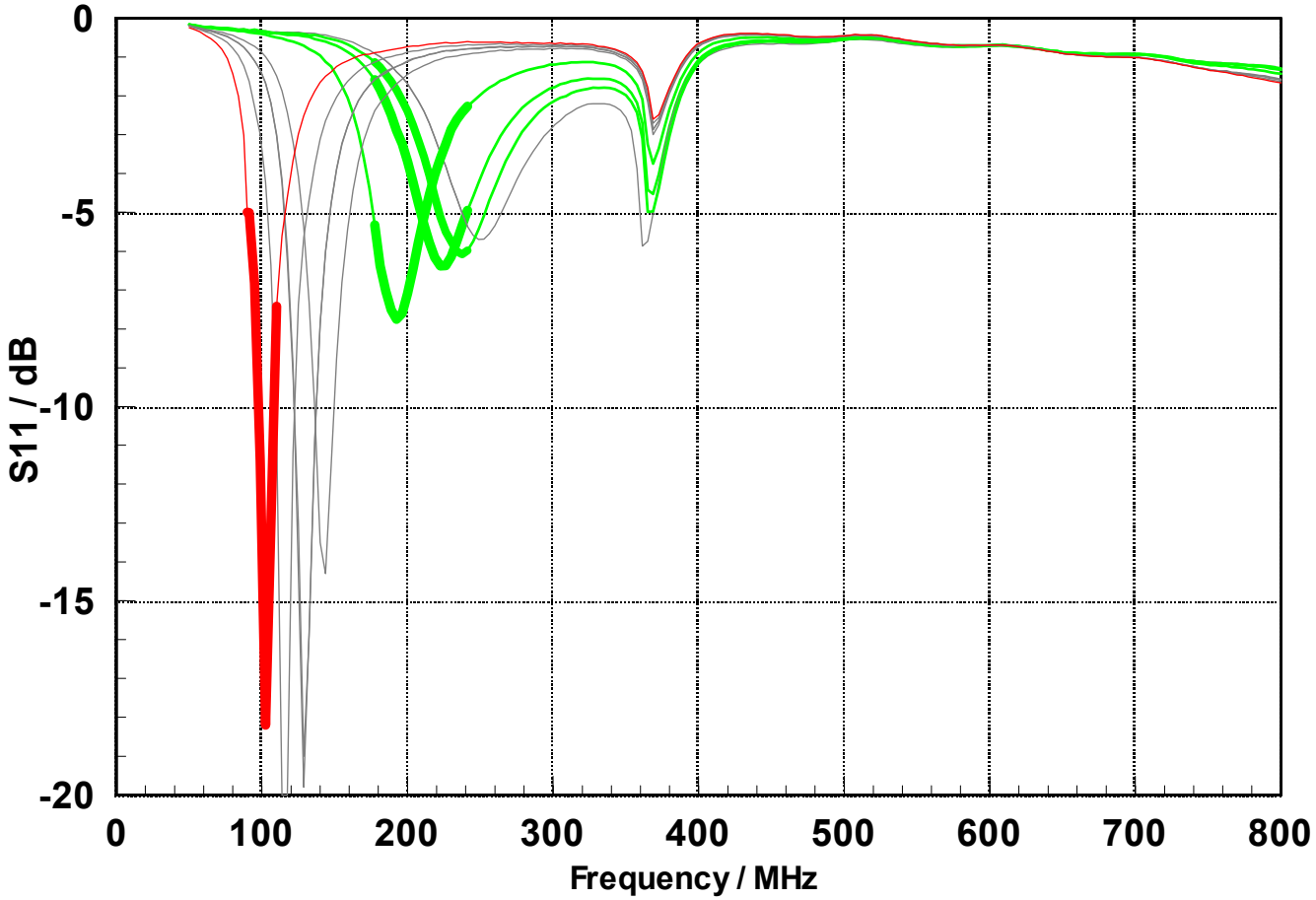
| Freq MHz | Nokia 5030 | Prototype | Radio set |
|---|---|---|---|
| 88.6 | 0 | 6 | 5 |
| 89.9 | 0 | 6 | 6 |
| 93.2 | 0 | 4 | 4 |
| 94.25 | 0 | 6 | 3 |
| 96.1 | 0 | 3 | 5 |
| 97.4 | 4 | 4 | 6 |
| 98.9 | 0 | 3 | 6 |
| 99.45 | 0 | 7 | 7 |
| 101.7 | 2 | 5 | 4 |
| 103.4 | 0 | 2 | 0 |
| 105.6 | 0 | 5 | 5 |
| 107.7 | 3 | 4 | 7 |
| Total | 9 | 56 | 58 |

# Add DAB band III (200MHz)

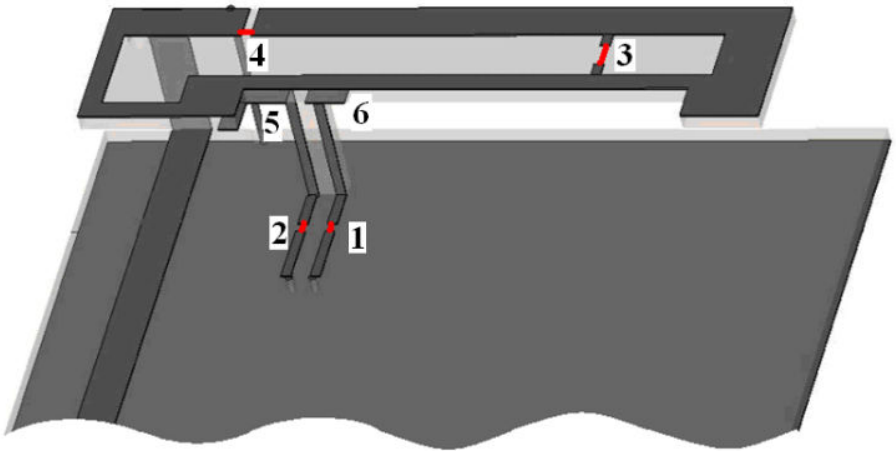



DC current route for Varactor1
DC current route for Varactor2

# Tunes FM and DAB

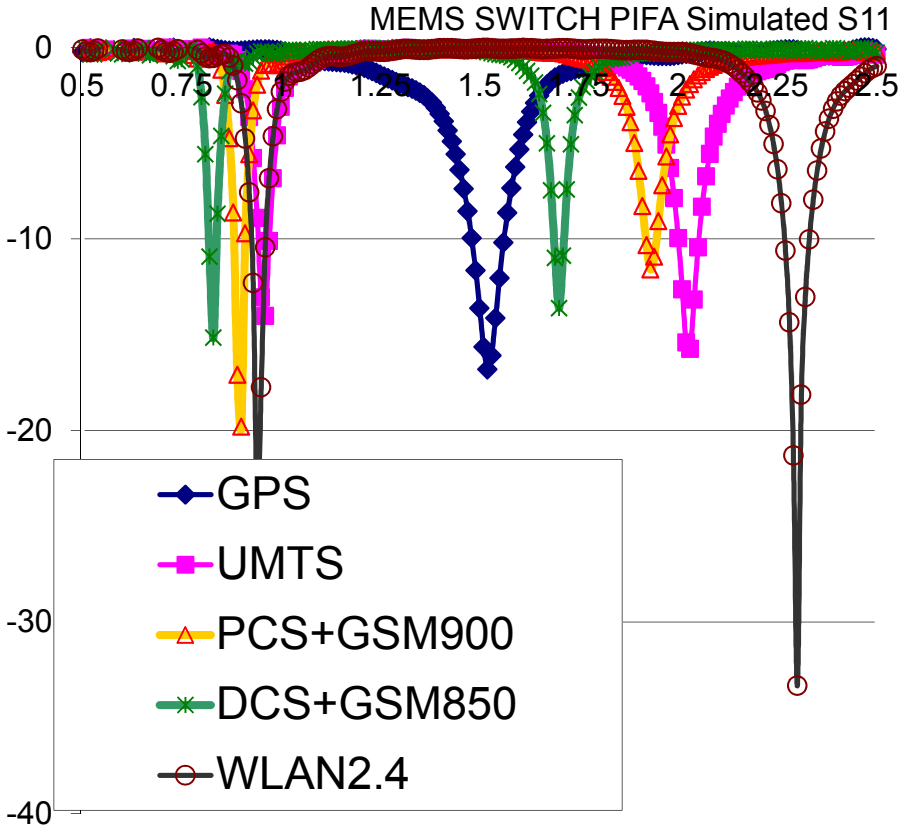


# MEMS switching reconfigurable PIFA geometry



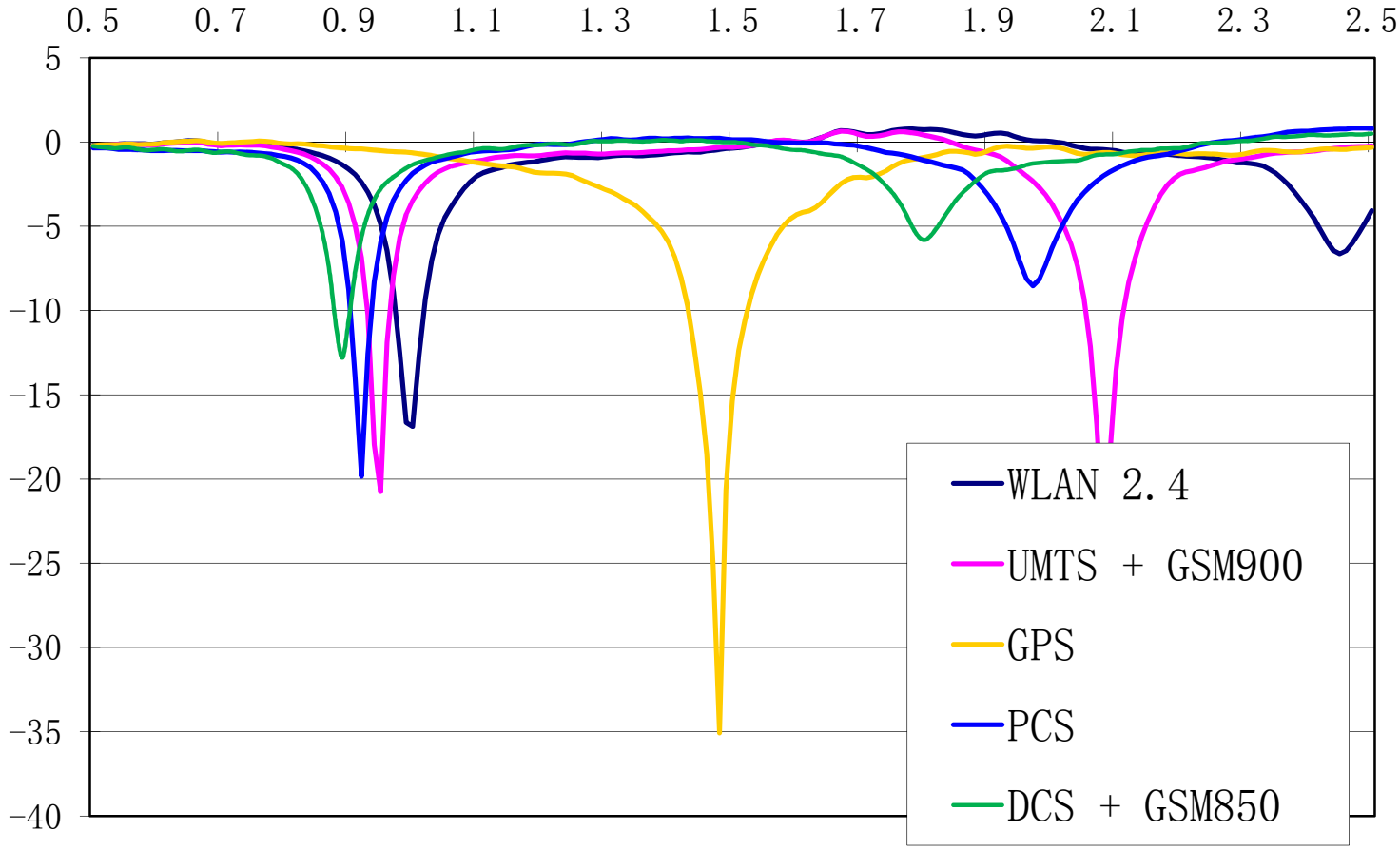

1 & 2 are the feed ports

4 MEMS switches

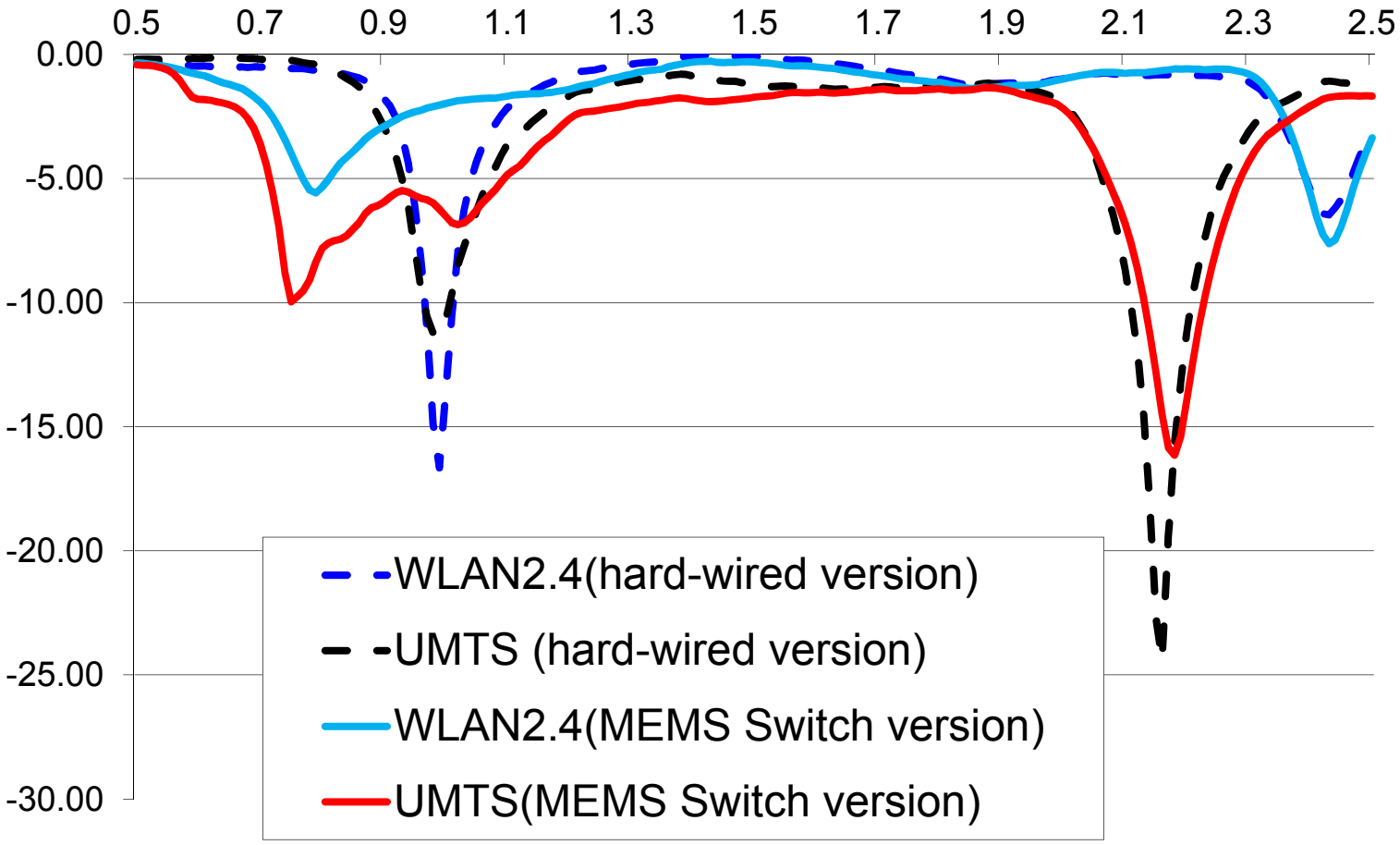


# •**Measured S11** Hard-wired version

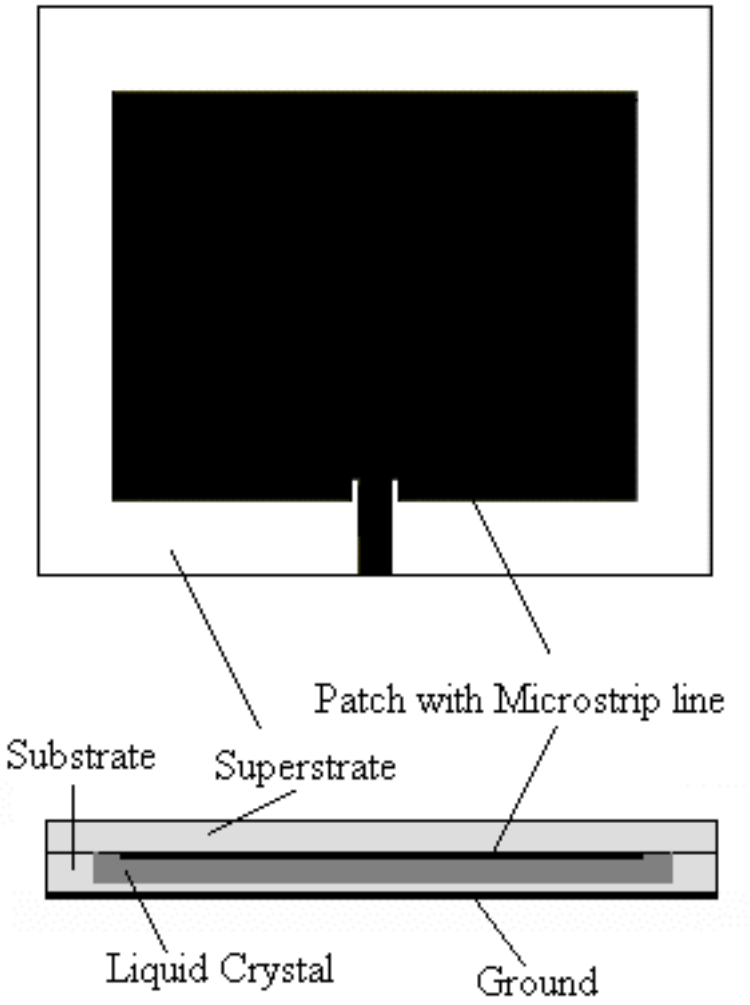
• (with direct metal connection  instead of electronic switches)



# Measurements – hard wire vs MEMs switch

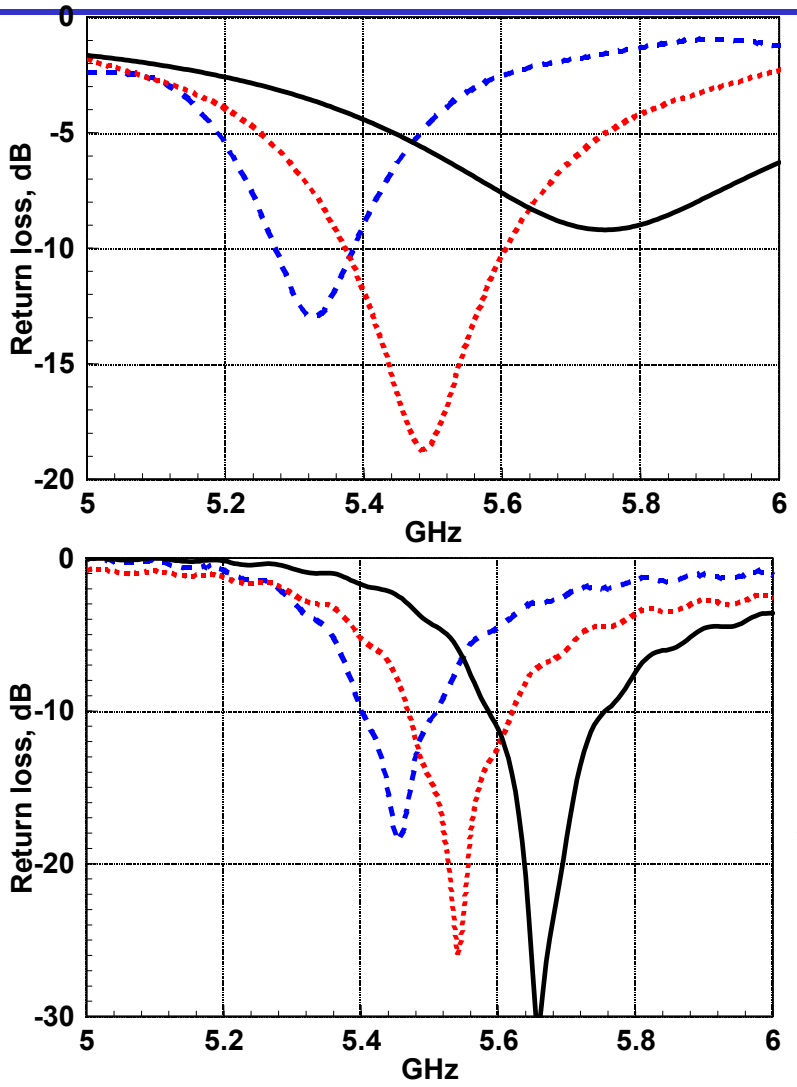


# Electronic tuning of the dielectric




- Taconic glass reinforced PTFE substrate, type TLY-5, 0.51 mm thick.
- A cavity was formed in central layer of TLY-5 substrate into which the LC was injected.
- The LC layer was 0.51 mm thick and extended 2 mm beyond the area of the patch.

# Return loss for LC tuned microstrip patch antenna




simulated

measured

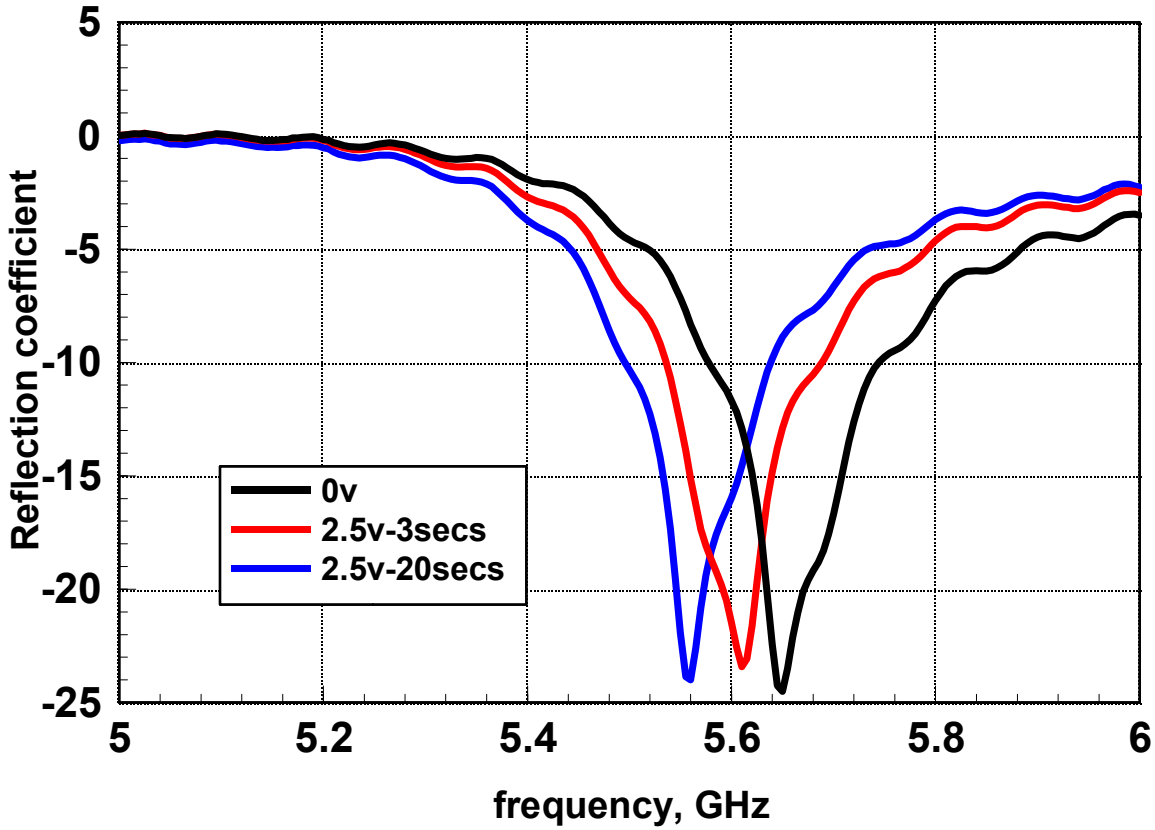
0 V bias — $\varepsilon_r$ =2.72, tanδ = 0.12

5 V bias ..... $\varepsilon_r$ =3.00, tanδ = 0.06

10V bias ..... $\varepsilon_r$ =3.17, tanδ = 0.02

Similar results at 2GHz

# Measured reflection coefficient under 2.5 v DC bias after 3 seconds and 20 seconds



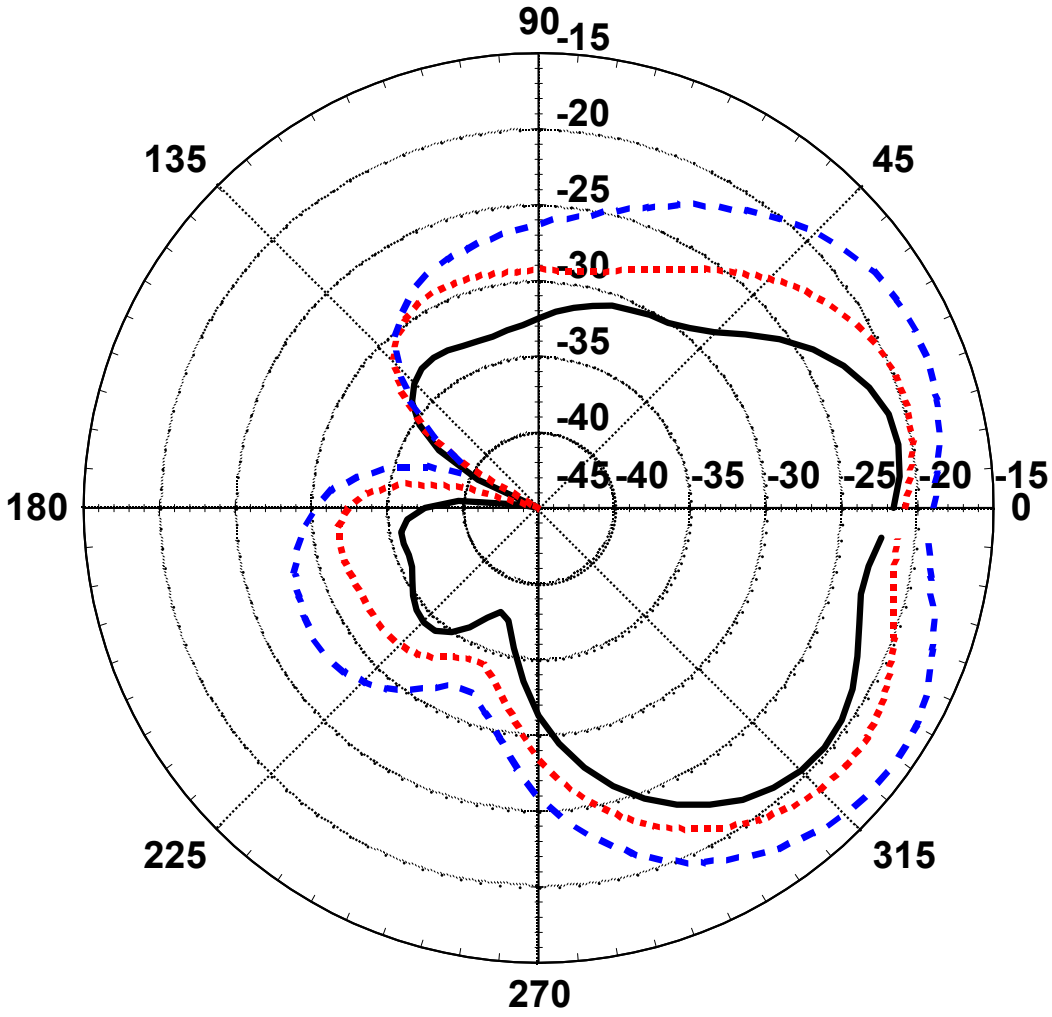
# Radiation patterns for LC tuned patch antenna - E-plane

$\varepsilon_r$ =2.72, tanδ = 0.12

$\varepsilon_r$ =3.00, tanδ = 0.06

$\varepsilon_r$ =3.17, tanδ = 0.02

Efficiencies 15-40%



# LC tuning summary

- At 5 GHz (0 – 10V bias)
- a tuning range of 8% simulated and 4% measured
- Efficiency
  - 14% at 5.75 GHz with $\varepsilon_r$ =2.72, tan$\delta$ = 0.12;
  - 24% at 5.5 GHz with $\varepsilon_r$ =3.00, tan$\delta$ = 0.06;
  - 40% at 5.3 GHz with $\varepsilon_r$ =3.17, tan$\delta$ = 0.02.

# Conclusions

Use single antenna for Multiple bands

- Reconfigurable antennas need matching circuits
- Tuning bandwidths look promising
- Variety of different tuning mechanisms
- A universal matching circuit is a goal
- Single or multiple feed points?
- MEMs switches – optimise bias configuration
- Liquid Crystal tunable antennas at low frequencies are lossy

*Thanks to Antenova for sponsoring project